

# **The Interaction Between Propagating Disturbances and Supercritical Marine Layers on the West Coast of the United States**

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## **LONG-TERM GOALS**

In the future, we hope to expand our investigations into the dynamics of the marine layer. We wish to investigate the relationship between the large scale, upper atmospheric forcing and the marine boundary layer response. Particularly important are trapped events in the marine layer and the dynamical implications of supercriticality of the marine boundary layer. In addition, we have a interest in long, internal gravity waves in the marine layer. The basic climatology and the spectrum based upon a time period greater than a year is needed. How are these waves generated? Do gravity waves have a significant effect on the surface wind stress, and if so, under what conditions? Finally, as satellite techniques improve, we would like to adapt remote sensing techniques to determining boundary layer conditions over the eastern sides of oceans.

## **OBJECTIVES**

The major objective is to develop a description of the summer marine boundary layer along the west coast. The data captured, and the description will be used to investigate coastally trapped waves in the marine layer, the nature of turbulence, the roll of gravity waves in the near shore, and the extent of supercriticality in the marine layer.

## **APPROACH**

Make summer surface and aircraft measurements along the California and Oregon coast. Combine other sounding and profiler measurements from other sources to make a data net that extends from San Diego, California to Newport, Oregon. Apply theories to and test hypothesis on the data network.

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## WORK COMPLETED

Thirteen automated stations were constructed rather than purchased to have properties that were not easily incorporated in purchased stations at a better price. Improvements include minute averages, the highest accuracy commercially available pressure sensor in a remote station, aspirated temperature and humidity sensors and memory logged on flash cards.

Stations deployed and maintained along the California coast and from 10 May through 15 October 1994.

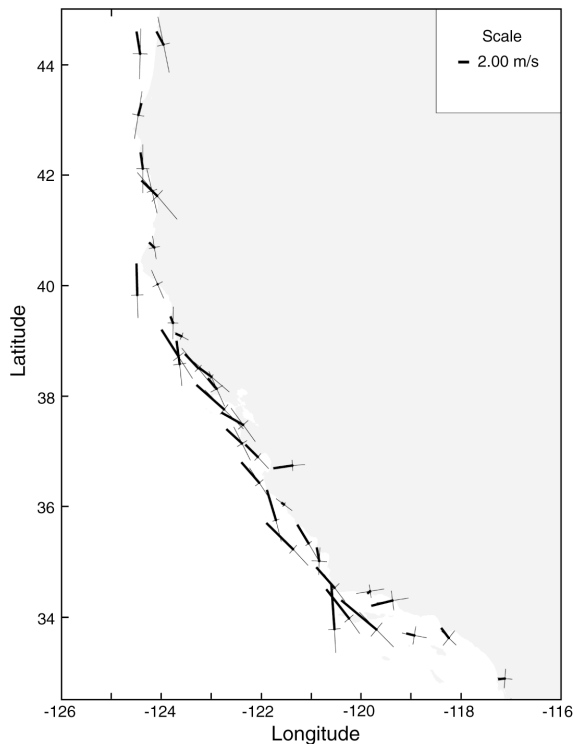
Twelve RAF C-130 flights were made along the central California Coast in July 1994.

Automated stations deployed and maintained along the West Coast between Piedras Blancas, CA to Gold Beach, OR from 12 May through 20 October 1996.

Papers have been published, or are accepted for publication on the 1994 field season and the 1996 field season. A manuscript has been submitted on the climatology of the west coast marine layer.

## RESULTS

A major trapped event occurred in the marine layer on 9/10 June. This was monitored by satellite, where a stratus cloud formed in the Southern California Bight, moved up the central coast. It continued up to bump into Pt Arena. Wind reversals at the NDBC buoys began near Santa Barbara, are strongest near Point Conception, and extend but weaken up to Pt Arena. The leading edge of this stratus event was very thin when we observed it on the ground approaching Pt Sur. Examination of the NWS upper air charts suggests to us that this event was a trapped event and not a directly forced response by a synoptic scale feature.



Offshore measurements of the coastal boundary layer were obtained during June 1994 using the UK Meteorological Office C-130 Hercules aircraft. The primary mission of this platform was to support the Monterey Area Ship Tracks (MAST) experiment. Dual purpose flights enabled us to obtain plume and cloud information in the vicinity of ships and also detailed measurements of the horizontal and vertical structure of the marine atmosphere over relatively warm water.

Figure 1. Caption at end of section.

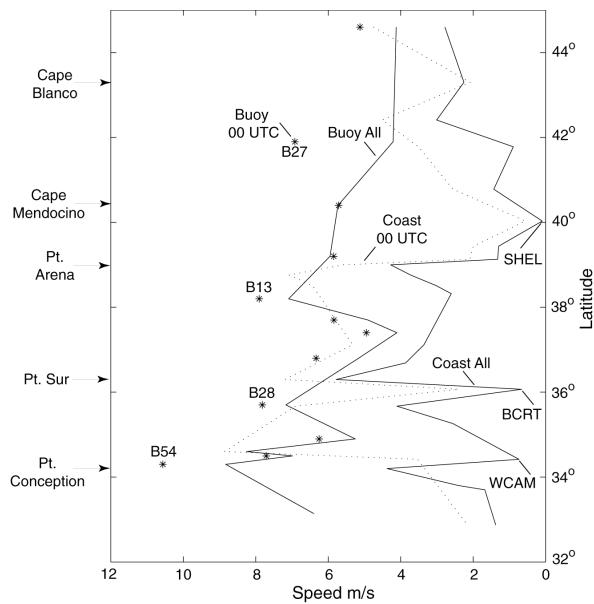
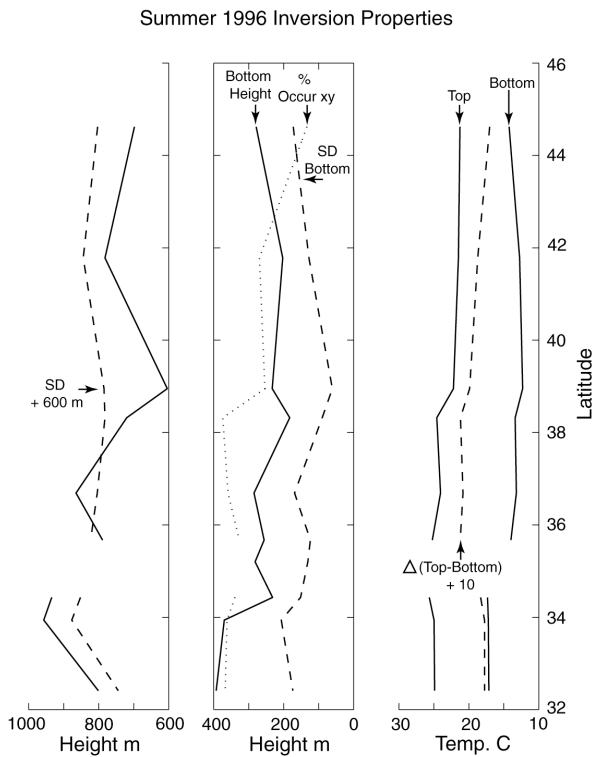


Figure 2. Caption at end of section.

In the cases under investigation we observe well-defined rolls that are the marine layer. Large gradients in sea surface temperature, variations in coastal topography, fetch, and the land-sea boundary all contribute to the heterogeneity of the coastal boundary layer. Rapid sampling of the boundary layer using aircraft allowed us to resolve spatially coherent fields. Combined with the long time series data from fixed measurement sites along the coast we will be able to obtain a comprehensive picture of the evolution of the marine boundary layer. There have been several numerical studies of the development of coherent rolls in the marine layer, particularly downstream of continents in large sea-air temperature gradients.



These convective rolls are often buoyancy driven as very cold air flows primarily shear-driven with distinct coherent spectral peaks in the velocity field. It is estimated that about 20% of the total wind stress and 10% of the turbulent kinetic energy and sensible heat flux is contributed by the rolls. Besides contributing to the fluxes the rolls determine fields of convergence and divergence that organize the stratus clouds in lines and may contribute to the longevity of ship tracks embedded in coastal stratus.

Measurements during the 1996 summer season show that when sea level wind speeds are fast, they are fast from Cape Mendocino to Pt Conception. During these times, the atmospheric marine layer Froude number is greater than one or supercritical for all of the major capes including Cape Mendocino, Pt Sur and Pt Conception. Extensive expansion fans radiate downwind and offshore of the Capes. A horizontal, coastal boundary in the marine layer is of the order 50 km wide at Cape Mendocino expands to 150-200 km wide along central California.

Figure 3. Caption at end of section.

Selected results are presented in three figures. They are:

Figure 1. Automated surface station mean speed and principle axis of Winds for June-July 1996. Mean is the arrow that flies with the wind. The cross at the end of the wind vector is the wind standard deviation with the long side the maximum magnitude and orientation and the short side the minimum

Figure 2. Wind speeds for stations in Fig. 1. vs latitude. Offshore stations means are the left line and coastal station means are the right line. Diurnal maximum at 1600 PST are shown for the offshore stations (asterisk) and coastal stations (dashed line).

Figure 3. Inversion Properties Left frame: Inversion top height (solid) and standard deviation + 600 m (dashed). Middle frame: Inversion base height (solid), standard deviation (dashed), and percent occurrence of inversion (dotted). Right frame: air temperature of the inversion top (solid, upper), air temperature of the inversion base (solid, lower), temperature difference top minus base +10 C (dashed).

## **IMPACT/APPLICATIONS**

The system of 13 automated meteorological stations may be used again for another season to make high quality, high frequency measurements of the coastal zone.

## **TRANSITIONS**

Data from this project was exchanged with NRL Monterey. This included surface observations and aircraft data that was used to test and evaluate the NRL COAMPS model. A copy of all surface hourly observations for the 1994 season has been transferred to Dr. Wendell Nuss in the Meteorology Department at the Naval Post Graduate School so that he may relate the synoptic scale with the local coastal response.

## **RELATED PROJECTS**

1. Within ONR: We have combined our data and work with Wendell Nuss (profiler and sounding data in the Monterey Bay area), and Bill Neff (Profilers at several sites). This forms an antenna to capture the structural aspects and investigate the dynamics of the marine layer. John Baine's light aircraft flight data is being used to shed light on the 9/10 June 1994 trapped event and conditions in the Santa Barbara Channel in 1996.
2. MAST: Sounding data study in the Monterey area that was taken during the MAST June 1994 intensive will be utilized. We are maintaining contact with MAST investigators to make available our data bank.

3. MMS: We are pooling data with this project to extend the data net coverage along the coast. The MMS study has 5 automated meteorological station in the Santa Barbara Channel which was useful for investigating the source of the 9/10 June 1994 trapped event and are helpful in looking other events that occurred in the 1996 summer season.

4. COST '96: The National Science Foundation funded Rogers and Dorman to make NCAR C-130 flights along the California coast in June 1996. Tracks were flown at multi levels down to 30 m and as far as 120 km offshore off the major topographic caps as Cape Mendocino, Pt Sur and Pt Conception.

## **PUBLICATIONS**

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